68.0127CNT1

UNITED STATES PATENT APPLICATION

for

THRU-TUBING SAND CONTROL METHOD AND APPARATUS

by

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and

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RELATED APPLICATIONS

This application is a continuation of U.S. patent application no. 09/631,859, filed August 3, 2000 which claims the benefit of U. S. Provisional Application No. 60/147,861, filed August 9, 1999.

BACKGROUND OF THE INVENTION

1. Field Of The Invention

The present invention relates to subsurface well equipment and, more particularly, to a thru-tubing sand control method and apparatus.

2. Description Of The Related Art

It is well known to those engaged in the exploration of oil and gas that certain subterranean hydrocarbon-producing formations have sand commingled with the hydrocarbons. For various reasons, which are well-known in the art, it is not desirable to produce the commingled sand to the earth's surface along with the hydrocarbons. As such, the industry developed sand-control completions that, in broad terms, include an upper and an optional lower, or sump, packer with various mechanisms disposed therebetween, including a closing sleeve and a sand screen. The upper packer, such as a seal bore retrievable packer, is initially connected to a service string, and the entire sand-control completion is lowered into the well on the service string until the sand screen is positioned adjacent the hydrocarbon-producing formation. If the well is cased, then the sand screen will be positioned adjacent perforations in the casing. A service tool in the service string is used to perform various functions and operations with regard

to the sand-control completion, including washing down the well bore as the string is run into the well bore, setting the packers, displacing fluids in the annulus above the upper packer, squeezing fluids into the production annulus and into the formation (e.g., through the casing perforations), packing gravel into the annulus between the sand screen and the formation, circulating fluids into the production annulus, and reverse-circulating fluids out of the service tool and service string. After all necessary operations have been carried out, and the sand-control completion is ready to produce the hydrocarbons to the earth's surface, the service string and tool are disconnected from the upper packer and removed from the well. A production tubing is then lowered into the well and connected to the upper packer, at which time production operations may commence. All of these functions and operations are known to those skilled in the art of sand-control and gravel pack completions.

It is also well known to those engaged in the exploration of oil and gas that there has been a move towards "smart" or "intelligent" well completions in which various mechanisms (e.g., temperature sensors, pressure sensors, flow-control devices, etc.) are attached to the completion and to one or more control cables or conduits (e.g., electrical, hydraulic, fiber optic, etc.) running to the earth's surface. The sensors transmit downhole well data to the earth's surface via the cables, or the flow-control devices may be remotely controlled from the earth's surface to control downhole fluid flow. A problem has developed, however, in applying this "smart" or "intelligent" concept to sand-control completions. Specifically, since sand-control completions have traditionally been run into the well on a service string, which is then removed and replaced with the production tubing, as explained above, it is not possible to have a continuous run of control cable to the earth's surface (or to some connection point above the upper packer) from a

sensor, flow-control device, etc. located below the upper packer. As such, if the traditional sand-control completion process is employed, there would be a section of control cable running from the sensor in the sand-control completion to the upper packer, and then another section of control cable running from the upper packer to the earth's surface (or to some connection point above the upper packer). This latter section of control cable would be part of the production tubing that is stabbed into the upper packer after removal of the service string. This would require that a "wet" connection be made at the upper packer between the two sections of control cable. For reliability reasons, it is preferred to avoid the use of "wet" connections, and, instead, run a continuous section of control cable from the various monitoring and fluid-control devices to the earth's surface (or other connection point above the upper packer). To achieve this goal, the completion hardware for sand control and all other completion hardware and tubing from the upper packer to the top of the well bore must be inserted into the well in one run. The present invention has been contemplated to meet this need while at the same time providing the completion with all the necessary pumping operations and hardware placement for sand control.

SUMMARY OF THE INVENTION

In a broad aspect, the invention may be a well completion comprising: a production tubing; an upper packer connected to a lower end of the production tubing; an intelligent device disposed below the upper packer; a continuous control cable running from the intelligent device to a connection point; and a sand screen disposed below the packer. Another feature of the present invention is that the completion may further include a first closing sleeve disposed

between the upper packer and the production tubing and remotely movable between an open position and a closed position. Another feature of the present invention is that the completion may further include at least one of a first polished bore receptacle disposed above the first closing sleeve and a second polished bore receptacle disposed between the first closing sleeve and the upper packer. Another feature of the present invention is that the completion may further include a second closing sleeve disposed between the upper packer and the sand screen and remotely movable between an open position and a closed position. Another feature of the present invention is that the control cable is sealably disposed through a port in the upper packer. Another feature of the present invention is that the completion may further include a washpipe movable from a first position to a second position, the washpipe restricting fluid flow through the sand screen when in the first position and permitting fluid flow through the sand screen when in the second position. Another feature of the present invention is that the completion may further include an upper washpipe nipple having an upper latching profile and a lower washpipe nipple having a lower latching profile, and wherein the washpipe includes a latching mechanism releasably engageable with the nipple profiles, the mechanism being engaged with the lower profile when in the first position and with the upper profile when in the second position. Another feature of the present invention is that the washpipe includes a gripping profile releasably engageable with a gripping mechanism on a service tool that is deployed through the production tubing. Another feature of the present invention is that the intelligent device is disposed in one of a first and a second position, the first position being between the packer and the sand screen, and the second position being below the sand screen. Another feature of the present invention is that the intelligent device may be disposed within the sand screen. Another feature of the present

invention is that the intelligent device is one of a temperature sensor, a pressure sensor, a flow-control device, a flow rate measurement device, an oil/water/gas ratio measurement devices, a scale detector, and a sand detection device. Another feature of the present invention is that the control cable includes at least one of an electrical cable, a fiber optic cable and a hydraulic control line. Another feature of the present invention is that the upper packer is a multiport packer and adapted to sealably pass at least one cable in the control cable therethrough. Another feature of the present invention is that the completion may further include a safety shear sub shearably disposed between the upper packer and the sand screen. Another feature of the present invention is that the completion may further include a lower packer disposed below the sand screen. Another feature of the present invention is that the completion may further include a valve-shifting collar disposed below the upper packer and above the sand screen, and adapted to shift a ball valve in a through-tubing service tool between open and closed positions. Another feature of the present invention is that the completion may further include a service tool disposed for longitudinal movement through the production tubing and adapted to perform sand-control operations in the completion. Another feature of the present invention is that the service tool includes a shifting profile releasably engageable with at least one of a shifting profile on a first closing sleeve disposed above the upper packer, a shifting profile on a second closing sleeve disposed below the upper packer, and a valve-shifting collar disposed below the upper packer. Another feature of the present invention is that the service tool includes a crossover housing having a packer-setting port adapted to direct pressurized fluid to hydraulically set the upper packer.

In another aspect, the invention may be a method of installing a sand-control completion, comprising: assembling the sand-control completion, the completion including a production tubing, an upper packer connected to a lower end of the production tubing, an intelligent device disposed below the packer, a continuous control cable running from the intelligent device to a connection point above the upper packer, and a sand screen disposed below the upper packer; and running the completion into a well and setting it in the well with the sand screen disposed adjacent a hydrocarbon-producing formation in a single trip. Another feature of the present invention is that the method further includes a washpipe disposed within the completion to restrict fluid flow through the sand screen, the method further including washing the well as the completion is being run into the well. Another feature of the present invention is that the method may further include running a service tool through the production tubing to perform at least one sand-control operation in the completion. Another feature of the present invention is that the method may further include running a service tool through the production tubing to shift a washpipe in the completion from a first position to a second position, the washpipe restricting fluid flow through the sand screen when in the first position and allowing fluid flow through the sand screen when in the second position. Another feature of the present invention is that the method may further include running a service tool through the production tubing to direct pressurized fluid to the upper packer to remotely control the upper packer. Another feature of the present invention is that the method may further include running a service tool through the production tubing to direct fluid to a well annulus below the upper packer, and squeezing fluid into a hydrocarbon-producing formation disposed adjacent the sand screen. Another feature of the present invention is that the method may further include stroking the service tool to a

circulating position, and circulating fluid from the production tubing into the annulus below the packer, through the sand screen, into a longitudinal bore of the service tool, through a crossover housing in the service tool, and upwardly to the earth's surface. Another feature of the present invention is that the fluid is directed from a crossover housing in the service tool to the earth's surface through the annulus above the upper packer. Another feature of the present invention is that the fluid is directed from a crossover housing in the service tool to the earth's surface through the production tubing. Another feature of the present invention is that the method may further include stroking the service tool to shift a ball valve therein from an open position to a closed position, raising the service tool, and circulating fluid from the earth's surface through a crossover housing in the service tool, into the production tubing, and upwardly to the earth's surface. Another feature of the present invention is that the method may further include engaging the service tool with a washpipe disposed in the completion and removing the service tool and washpipe from the completion.

In another aspect, the invention may be a washpipe assembly for use in a sand-control completion having a sand screen disposed below an upper packer, the washpipe assembly comprising: a washpipe having an upper end and a lower end, the washpipe being remotely shiftable from a first position to a second position, the washpipe restricting fluid flow through the sand screen when in the first position and permitting fluid flow through the sand screen when in the second position, and the washpipe being in the first position and releasably connected to the sand-control completion when the sand-control completion is being run in to a well. Another feature of the present invention is that the assembly may further include a lower annular seal disposed adjacent the lower end of the washpipe; and an upper annular seal disposed adjacent the

upper end of the washpipe, the upper end of the washpipe being sealably disposed above the sand screen and the lower end of the washpipe being sealably disposed below the sand screen when the washpipe is in the first position. Another feature of the present invention is that the completion may further include an upper washpipe nipple having an upper latching profile and a lower washpipe nipple having a lower latching profile, and wherein the washpipe includes a latching mechanism releasably engageable with the nipple profiles, the mechanism being engaged with the lower profile when in the first position and with the upper profile when in the second position. Another feature of the present invention is that the latching mechanism is a collet. Another feature of the present invention is that the washpipe further includes a gripping profile releasably engageable with a gripping mechanism on a service tool that is deployed through a production tubing.

In another aspect, the invention may be a well completion comprising: a production tubing; an upper packer connected to a lower end of the production tubing; a sand screen disposed below the packer; and a through-tubing service string and tool adapted to be deployed through the production tubing for performing sand-control operations within the completion. Another feature of the present invention is that the completion may further include at least one of (1) a flowpath above the upper packer through an inner annulus formed between the service string and the production tubing and (2) a flowpath above the upper packer through a well annulus formed between the production tubing and a well bore. Another feature of the present invention is that the service tool includes a shifting profile releasably engageable with at least one of a shifting profile on a first closing sleeve disposed above the upper packer, a shifting profile on a second closing sleeve disposed below the upper packer, and a valve-shifting collar

disposed below the upper packer. Another feature of the present invention is that the service tool includes a port adapted to direct pressurized fluid to hydraulically set the upper packer. Another feature of the present invention is that the completion may further include an intelligent device disposed below the upper packer; and a continuous control cable running from the intelligent device through a port in the upper packer to a connection point. Another feature of the present invention is that the completion may further include a washpipe movable from a first position to a second position, the washpipe restricting fluid flow through the sand screen when in the first position and permitting fluid flow through the sand screen when in the second position. Another feature of the present invention is that the completion may further include an upper washpipe nipple having an upper latching profile and a lower washpipe nipple having a lower latching profile, and wherein the washpipe includes a latching mechanism releasably engageable with the nipple profiles, the mechanism being engaged with the lower profile when in the first position and with the upper profile when in the second position. Another feature of the present invention is that the washpipe includes a gripping profile releasably engageable with a gripping mechanism on a service tool that is deployed through the production tubing.

BRIEF DESCRIPTION OF THE DRAWINGS

Other features and advantages of the present invention will become more fully apparent from the following detailed description, appended claims, and the accompanying drawings in which:

Figures **1A-1B** illustrate a longitudinal view in partial cross-section of one embodiment of the present invention, with the completion in an installation position.

Figures **2A-2B** illustrate a longitudinal view in partial cross-section of the embodiment shown in Figures **1A-1B**, only now in a packer-setting and squeeze position.

Figures **3A-3B** illustrate a longitudinal view in partial cross-section of the embodiment shown in Figures **1A-1B**, only now in a circulating position.

Figures **4A-4B** illustrate a longitudinal view in partial cross-section of the embodiment shown in Figures **1A-1B**, only now in a reverse circulating position.

Figures **5A-5B** illustrate a longitudinal view in partial cross-section of the embodiment shown in Figures **1A-1B**, only now illustrating removal of a washpipe.

Figures **6A-6B** illustrate a longitudinal view in partial cross-section of another embodiment of the present invention, with the completion in an installation position.

Figures **7A-7B** illustrate a longitudinal view in partial cross-section of the embodiment shown in Figures **6A-6B**, only now in a packer-setting and squeeze position.

Figures **8A-8B** illustrate a longitudinal view in partial cross-section of the embodiment shown in Figures **6A-6B**, only now in a circulating position.

Figures **9A-9B** illustrate a longitudinal view in partial cross-section of the embodiment shown in Figures **6A-6B**, only now in a reverse circulating position.

Figures **10A-10B** illustrate a longitudinal view in partial cross-section of the embodiment shown in Figures **6A-6B**, only now illustrating removal of the washpipe.

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While the invention will be described in connection with the preferred embodiments, it will be understood that it is not intended to limit the invention to those embodiments. On the

contrary, it is intended to cover all alternatives, modifications, and equivalents as may be included within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

For purposes of this description, the terms "upper," "lower," "uphole," and "downhole" are relative terms to indicate position and direction of movement in easily recognized terms. Usually these terms are relative to a line drawn perpendicularly downward from the center of the borehole at the earth's surface, and would be appropriate for use in straight, relatively vertical wellbores. However, when the wellbore is highly deviated, such as from about horizontal to about 60 degrees from vertical, or if there are multiple laterals, these usually comfortable terms to persons skilled in the art may not make sense. Use of these terms are for ease of understanding as an indication to what relative position or movement would be if the well were vertical, and should not be construed to limit the scope of the invention.

Referring to the drawings in detail, wherein like numerals denote identical elements throughout the several views, one embodiment of the sand-control completion **10** of the present invention is shown in Figures **1A-1B** disposed in a casing **12** in an installation configuration. As shown in Figures **1A-1B**, the completion **10** may include a production tubing **14** disposed within a well bore **13** formed by the casing **12**, and having a lower end **16** connected to an upper packer **18**. The production tubing **14** may be any type of tubing known to those of skill in the art, including coiled tubing. A first closing sleeve **20** may be connected between the upper packer **18** and the production tubing **14**, and is generally closed when the completion **10** is being run into

the well bore **13**. The completion **10** may include a first polished bore receptacle **15** above the first closing sleeve **20** and a second polished bore receptacle **17** below the first closing sleeve **20** and above, or part of, the upper packer **18**, the function of which will be explained below. The completion **10** further includes a sand screen **21** (see Figure **1B**) below the upper packer **18**, and may further include a lower, or sump, packer **23** below the sand screen **21**; the sump packer **23** is not necessary unless isolation below the sand screen **21** is desired. As shown in Figure **1B**, the sand screen **21** is positioned adjacent a hydrocarbon-producing formation **25**. If the well bore **13** is cased, as shown, then communication is established between the formation **25** and the well bore **13** through a number of perforations **27** in the casing **12**.

The completion **10** may further include a second closing sleeve **22** between the upper packer **18** and the sand screen **21**, a first intelligent device **24** (e.g., pressure sensor, temperature sensor, flow control device, etc.) between the upper packer **18** and the sand screen **21**, a safety shear sub **26**, and a second intelligent device **28** below the sand screen **21**, such as between the sand screen **21** and the lower packer **23** (see Figure **1B**), as well as other intelligent devices and other components. The second closing sleeve **22** is closed when the completion **10** is being run into the well bore **13**. For purposes of this invention the term "intelligent device" includes any device used in "intelligent" or "smart" well completions, including but not limited to devices such as temperature sensors, pressure sensors, flow-control devices, flow rate measurement devices, oil/water/gas ratio measurement devices, scale detectors, sand detection device, and the like. The completion **10** may include any number and any combination of these intelligent devices below the upper packer **18**. The safety shear sub **26** is disposed above the sand screen **21**, and allows the portion of the completion **10** above the shear sub **26** to be removed in the

event that the portion of the completion **10** below the shear sub **26** becomes stuck or if the string must be pulled for other reasons. A continuous section of control conduit **30** is connected between a "connection point" and the intelligent devices **24** and **28**. The "connection point" may be located at the earth's surface or at some intermediate point between the upper packer **18** and the earth's surface. For example, in a multilateral well, the "connection point" may be at an inductive coupler or downhole controller located between the earth's surface and the upper packer **18**. As used here, the term "continuous" does not mean that there are no connections between discrete sections of control conduit **30** between the connection point and the intelligent devices **24** and **28**, but, instead, that all such connections are made in a sufficiently sealed manner at the connection point, not remotely after the sections of control conduit are already inside the well (i.e., none of the connections is a "wet" connection). In a specific embodiment, the control conduit **30** may include a plurality of cables, such as one or more electrical, fiber optic or hydraulic cables for transmitting data, signals, pressurized fluid, power, etc. from the intelligent devices **24** and **28**. It is noted that the upper packer **18** should be of the "multiport" type (i.e., one that allows for passage of a plurality of control lines therethrough), also known as a "control line bypass" packer, and be capable of sealably passing the various cables **30** therethrough while at the same time maintaining pressure integrity. As such, the various cables **30** pass through the upper packer **18** and connect to the various intelligent devices (e.g., **24** and **28**). In a specific embodiment, the intelligent device **28** may be an in-line flow control device **28** disposed between the sand screen **21** and the sump packer **23** for control of production from below the sump packer **23**. It is further noted that a hydraulic cable within the control conduit **30** may be connected to the upper packer **18** for remotely controlling the setting and releasing thereof. In addition to

using hydraulics to set the multiport upper packer **18**, there are a variety of other ways, as known to those of skill in the art, by which the packer **18** may be set, including by tubing, control line, or any other method known to those of skill in the art.

With reference to Figure **1B**, the sand-control completion **10** may further be provided with a washpipe **32** having an upper end **34** and a lower end **36**. During the installation mode, as shown in Figures **1A** and **1B**, the washpipe **32** is sealably disposed within and through the sand screen **21**, with its upper end **34** sealably disposed above the sand screen **21** and its lower end **36** sealably disposed below the sand screen **21**. The lower end **36** of the washpipe **32** may include a lower annular seal **37** that may be sealably received within the sump packer **23** or another polished bore receptacle to prevent fluid flow through the sand screen **21**. The upper end **34** of the washpipe **32** may include an upper annular seal **39** that may be sealably received within a seal bore **41** of a lower washpipe nipple **42**. The completion **10** may further include an upper washpipe nipple **38** having an upper latching profile **40** disposed about its interior, and the lower washpipe nipple **42** may have a lower latching profile **44** disposed about its interior. Both nipples **38** and **42** are disposed between the upper packer **18** and the sand screen **21**. The upper end **34** of the washpipe **32** may further include a latching mechanism or profile **46** disposed about its exterior that is releasably engageable with the upper and lower latching profiles **40** and **44** on the upper and lower washpipe nipples **38** and **42**, respectively. In a specific embodiment, the latching mechanism **46** may be a collet connected to the upper end **34** of the washpipe **32**. When the completion is in its installation configuration, as shown in Figures **1A** and **1B**, the latching mechanism **46** on the upper end **34** of the washpipe **32** is releasably engaged with the lower latching profile **44** of the lower washpipe nipple **42**. The upper end **34** of the washpipe **32**

may further include a gripping profile **48** disposed about its interior, the purpose of which will be explained below. The washpipe **32** functions to isolate the sand screen **21** and allow washdown circulation capability as the completion **10** is being run into the well bore **13**. By isolating the sand screen **21** with the washdown pipe **32**, it is possible to pump washdown fluid to the bottom of the completion **10** as it is being run into the well bore **13**.

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Thus far, two of the unique features of the present invention have been identified, one of them being that the completion **10** is installed in one trip, instead of two, and provides a continuous control conduit **30** from the intelligent devices **24** and **28** to the connection point, thereby avoiding the use of wet connections. Another of the unique aspects of the present invention identified above is that the washpipe **32** allows the completion **10** to be installed in a single trip without sacrificing the ability to perform washdown circulation functions as the completion **10** is being run into place. Another unique feature of the present invention will now be described, namely, the ability to run a service tool inside, or through, the production tubing **14** to perform the various necessary sand-control pumping and circulating operations.

Referring now to Figures **2A** and **2B**, a thru-tubing service string **50** is shown disposed within the production tubing **14** and connected to a service tool **51**. The service string **50** may be any type of string known to those of skill in the art, including but not limited to jointed tubing, coiled tubing, etc. The service tool **51** includes a lower end **52** disposed within the sand screen **21**. The lower end **52** of the service tool **51** is provided with a gripping mechanism **54** that is releasably engageable with the gripping profile **48** at the upper end **34** of the washpipe **32**. By releasably engaging the gripping mechanism **54** on the service tool **51** with the gripping profile **48** on the washpipe **32**, the service tool **51** may be used to remotely grab and move the washpipe

32 from its first, or sand-screen isolating, position, shown in Figure **1B**, to its second position, shown in Figure **2B**. In this second position, circulation is permitted from a well annulus **64**, formed between the production tubing **14** and the well casing **12**, through the sand screen **21** and into the production tubing **14**. The service tool **51** may be similar in structure and operation to service tools of the type discussed above that have been traditionally used in deploying sand-control completions, and may include a standard crossover housing **56** and a ball valve **58**, except that the service tool **51** of the present invention is run through the tubing **14** and is not provided with the structure used in previously existing service tools to attach to and set the upper packer **18**. While the service tool **51** is shown with a ball valve **58**, that should not be taken as a limitation and the present invention is intended to cover service tools **51** that lack a ball valve **58**. For example, the service tool **51** may be of the type that is manipulated by movement of the service tool **51** relative to the upper packer **18**. In addition, in those situations where it is desired to provide the completion **10** with washdown capability, another difference is that the service tool **51** is provided with the above-discussed gripping mechanism **54** at its lower end **52** for remotely shifting the washpipe **32**, whereas previously the washpipe **32** was part of the service tool.

With reference to Figure **2A**, the completion **10** may include a valve-shifting collar **55** disposed below the second closing sleeve **22** and above the sand screen **21**. Movement of the ball valve **58** relative to the collar **55** will open and close the ball valve **58**. The collar **55** should be located so as to be above the upper end **34** of the washpipe **32** when the washpipe **32** is in its first and second positions. The service tool **51** may be provided with a shifting profile **59** for mating with: a shifting profile **29** on the first closing sleeve **20**; a shifting profile **31** on the

second closing sleeve **22**; and the collar **55**. As the service tool **51** is run through the tubing **14** and into the portion of the completion **10** below the upper packer **18**, the shifting profile **59** is used to shift the first and second closing sleeves **20** and **22** to their open positions. It is noted that the first and second closing sleeves **20** and **22** may also be shifted between their open and closed positions by any known intervention tool. The service tool **51** is then set in a first position, as shown in Figures **2A** and **2B**, by engaging the shifting profile **59** with the collar **55**. It is further noted that, if a washpipe **32** is included, the completion **10** should be provided with adequate blank pipe **33** and **35** between the gripping mechanism **54** at the lower end **52** of the service tool **51** and the ball valve **58** to allow enough stroke for the service tool **51** to perform the various pumping operations.

If the upper packer **18** is to be hydraulically set, then the service tool **51** should be provided with the necessary structure to direct pressurized fluid to set the upper packer **18**. In this regard, in a specific embodiment, the crossover housing **56**, shown in Figure **2A**, may be provided with a packer-setting port **60** in communication with a longitudinal passageway **62** in the crossover housing **56**. When the completion **10** and the service tool **51** are in the configuration shown in Figures **2A** and **2B**, the first closing sleeve **20** is open thereby establishing fluid communication with the well annulus **64**. This permits fluid flow from the annulus **64** through the first closing sleeve **20** and into the longitudinal passageway **62** in the crossover housing **56**, as indicated by arrows **66** and **68**. Pressurized fluid is then directed from the longitudinal passageway **62** through the packer-setting port **60**, as indicated by arrow **70**, to hydraulically set the upper packer **18**. As noted above, this is just one example of how to set the upper packer **18** and should not be taken as a limitation on the scope of the invention.

Figures **2A** and **2B** also illustrate the completion **10** and the service tool **51** in a squeeze configuration. It is noted that, in this configuration, the gripping mechanism **54** at the lower end **52** of the service tool **51** has been used to move the washpipe **32** from its first, or sand-screen isolating, position, as shown in Figure **1B**, to its second position, as shown in Figure **2B**. It is further noted that for all remaining operations the gripping mechanism **54** at the lower end **52** of the service tool **51** will stay below the gripping profile **48** at the upper end **34** of the washpipe **32** so long as the washpipe **32** remains in the completion **10**. In the position shown in Figures **2A** and **2B**, fluid represented by arrow **72** at the top of Figure **2A** moves downwardly within the production tubing **14** and is directed through a radial port **74** in the crossover housing **56** and through the open second closing sleeve **22** into the annulus **64** below the upper packer **18**, as indicated by arrow **76**. It is noted that the service tool **51** may include one or more annular seals **53** to prevent downward fluid flow into the space between the service tool **50** and the completion **10**. The fluid continues down the annulus **64** and is squeezed into the formation **25** through the perforations **27**, as indicated, for example, by arrow **78**. The ball valve **58** is closed during this operation.

Figures **3A** and **3B** illustrate the completion **10** in a circulating configuration, which has been achieved by stroking the service tool **51** to open the ball valve **58**, in the manner discussed above. In this configuration, fluid flow is directed down the production tubing **14** and into the annulus **64** below the upper packer **18** in the same manner as discussed above with regard to Figures **2A** and **2B**. Instead of squeezing the fluid into the formation **25**, as with regard to Figure **2B**, the fluid here is circulated through the sand screen **21** and into a longitudinal bore **51a** of the service tool **51**, as indicated by arrow **80**. Fluid flow then continues upwardly through the open

ball valve **58**, into the longitudinal passageway **62** in the crossover housing **56**, out through the open first closing sleeve **20** and into the annulus **64** above the upper packer **18** for circulation to the earth's surface. As is well known to those of skill in this art, gravel may be delivered and packed into the annulus **64** between the casing **12** and the sand screen **21** during this operation. In addition to using the present invention for gravel packing purposes, it may also be used for many other purposes, such as for cleaning, stimulating and fracturing, to name a few.

Figures **4A** and **4B** illustrate the completion **10** in a reverse circulating configuration, which has been achieved by stroking the service tool **51** to close the ball valve **56**, in the manner discussed above, and then by raising the service tool **51** upwardly to establish fluid communication from the well annulus **64** through the open first closing sleeve **20**, through the radial port **74** in the crossover housing **56**, and into the service string **50**, as indicated by arrow **82**. It is noted that the second closing sleeve **22** is closed by the service tool **51** when the service tool **51** is moved upwardly to its position as shown in Figures **4A** and **4B**. It is further noted that fluid flow downwardly into the space between the service tool **51** and the second polished bore receptacle **17** is prevented by the seals **53**. Likewise, another annular seal **57** disposed about the service tool **51** is disposed within the first polished bore receptacle **15** when the service tool **51** is in this position to prevent upward fluid flow into the annular space between the service string **50** and the production tubing **14**. Finally, it is noted with reference to Figure **4B** that the gripping profile **54** at the lower end **52** of the service tool **51** is below the gripping profile **48** at the upper end **34** of the washpipe **32** when the service tool **51** and the completion **10** are in the reverse circulating configuration.

With reference to Figures **5A** and **5B**, the service tool **51** is shown with the gripping profile **54** on the lower end **52** of the service tool **51** engaged with the gripping profile **48** at the upper end **34** of the washpipe **32**. The service tool **51** and the washpipe **32** are then retracted upwardly to the earth's surface, at which time production operations may commence.

Another embodiment of the completion **10** of the present invention is shown in Figures **6A** through **10B**. The structure and operation of this embodiment is very similar to the embodiment described above with regard to Figures **1A** through **5B**, with a difference being that the embodiment shown in Figures **6A** through **10B** lacks a closing sleeve and first polished bore receptacle above the upper packer **18**. As such, in this embodiment, fluid circulation between the production tubing **14** and the annulus **64** above the upper packer **18** is not possible. Fluid flow is allowed, however, through an inner annulus **84** formed between the service string **50** and the production tubing **14**, as shown at the top of Figures **7A**, **8A** and **9A**. The structure and operation of the service string **50** and the service tool **51** are the same in this embodiment as is discussed above with regard to the other embodiment, with the only minor difference being that certain seals may be omitted here since there is no polished bore receptacle above the upper packer **18** to seal in.

It is to be understood that the invention is not limited to the exact details of construction, operation, exact materials or embodiments shown and described, as obvious modifications and equivalents will be apparent to one skilled in the art. For example, the various embodiments of the completion **10** of the present invention are shown disposed within a vertical, cased well bore. This should not be taken as a limitation. Instead, the invention is equally application to open

hole and/or horizontal well bores. Accordingly, the invention is therefore to be limited only by the scope of the appended claims.